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NAVAL OCEAN SYSTEMS CENTER
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NAVAL OCEAN SYSTEMS CENTER, SAN DIEGO, CA 92152

AN ACTIVITY OF THE NAVAL MATERIAL COMMAND

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Commander

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Technical Director

ADMINISTRATIVE INFORMATION

The scope of the Naval Ocean Systems Center's technical effort is wide, being sponsored by a variety of agencies. Since the Center is directed by the Naval Material Command, its primary tasks are based on requirements defined by the Chief of Naval Operations and the Naval Material Command.

Of the work described in this report, the primary tasks were sponsored by offices within the Sea, Facilities, Air, and Electronic Systems Commands of the Naval Material Command. Additional tasks were sponsored by the Office of Naval Research, the Advanced Research Projects Agency, the Atomic Energy Commission, and some active Fleet commands.

The tasks reported fall into all the areas of the Center's technological scope, in which it:

Conducts research, development, test, and evaluation of systems and techniques that provide the Navy with safe and reliable means for the accomplishment of engineering projects in the sea – employing men, manned submersibles, and unmanned, remotely controlled machine systems.

Develops deep-submergence technology in general support of present and future Navy operational requirements.

Applies principles of ocean engineering to the design of systems for the Navy's combat and noncombat missions.

Supports the Navy's Fleet operations by satisfying their quick-response needs in hardware for undersea operations.

Released by
HR TALKINGTON, Head
Ocean Technology Department

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This document presents summaries of projects completed, underway, or in planning within the Naval Ocean Systems Center as of March 1978. It is intended to demonstrate the scope of NOSC's ocean engineering effort and provide specific examples of the Center's capabilities in this area. The projects described exemplify research, development, test, or evaluation in the following areas: remotely controlled underwater vehicles, manned submersibles with panoramic visibility, launch and recovery of submersibles, pressure-resistant hulls and materials, diver equipment, salvage systems, undersea imaging, untethered deep-ocean buoys, stationary floating ocean platforms, and

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Stable ocean platforms	Systems management
Self-propelled ocean platforms	Underwater cables
Sonar detection	Computerized simulation
Pressure-resistant electronic components	Immersion
Inflatable structures	Radio isotope batteries
Air-film technology	Systems engineering

20.

self-propelled ocean platforms. Additional projects include study of the effects of ocean submersion on radio-isotope power units, application of system integration techniques to the development and deployment of undersea sensor arrays, and provision of engineering support for Fleet units and research and development facilities.

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UNMANNED VEHICLES

Although manned submersibles can, properly equipped, perform any conceivable mission in the ocean, in many cases they do so only at great cost and some risk to their crews. Thus, a program was initiated at NOSC for the development of tethered unmanned, remote-controlled work systems. These systems have proven to be very reliable ocean engineering tools to both the oceanographic investigator and the Navy. The continuing research at NOSC assures that each generation of such systems is significantly improved in operational capabilities, while operational costs and shipboard support requirements are substantially decreased. Work has recently commenced on a new generation of vehicles which show great promise for future operations: unmanned free-swimming vehicles which incorporate artificial intelligence.

- current projects

CABLE-CONTROLLED UNDERWATER RECOVERY VEHICLE (CURV II)

CURV II is an unmanned tethered submersible capable of operating to 2500 feet. It is the successor to CURV I, which recovered the H-bomb off the coast of Spain in 1966. In configuration, CURV II is typical of most unmanned vehicles; it has an open rectangular framework to support the sensors and tools, two horizontal propulsion motors to drive and steer the vehicle, one vertical motor for close vertical control, and buoyancy of approximately 25 pounds. The vehicle is 6.5 by 6.5 by 15 feet long, weighs 3000 pounds in air, and operates at submerged speeds to 3 knots. The sensors include a Straza 500 active-passive sonar, acoustic altimeter and depthometer, compass, two Hydroproducts television cameras with lights, and an EG&G 35-mm still camera with strobe. One major feature of all surface-powered vehicles is that their bottom time is only restricted by the time or ability of the surface support craft to stay on station.

The CURV II system consists of the vehicle, control cable, and control console. Although it normally operates from the YFNX 30 surface support ship, the system can be air transported to operate from any surface ship of opportunity. It is primarily used for recovery of practice torpedoes from NOSC ranges.

CABLE-CONTROLLED UNDERWATER RECOVERY VEHICLE (CURV III)

CURV III, a more modern and greater-depth version of CURV II, is capable of operating at depths to 7000 feet. The CURV III system is comprised of the vehicle, control cable, and control console. Although it normally operates from the YFNX 30, the system is designed so that all major operational components can be disassembled, air transported to a work site, and installed on any surface craft that has adequate deck space. The vehicle normally carries a hydraulically operated claw for attaching and recovering items, such as ordnance, from the ocean floor. For special tasks, the claw is removed and replaced by a variety of grasping, cutting, or working tools. The vehicle also contains the necessary equipment for searching, locating, and documenting the lost item. Control of the vehicle and monitoring of operations are done in the control van. The vehicle is 6.5 by 6.5 by 15 feet long and weighs 4500 pounds in air. It normally operates to depths of 7000 feet but can be modified for emergency operations to 10 000 feet. Its instrument suite includes a Straza 500 active-passive sonar with transponder interrogation capability, acoustic altimeter and depthometer, compass, two Hydroproducts television cameras with lights, and an EG&G 35-mm still camera with strobe.

CURV III is a versatile underwater vehicle that can be readily modified to accommodate a wide variety of underwater tasks. It has demonstrated its search and recovery capabilities off the west coast as well as in the Atlantic Ocean, most notably during the 1973 rescue of the PISCES III submersible off Ireland.

REMOTE UNMANNED WORK SYSTEM (RUWS)

Under the Deep-Ocean Technology (DOT) program, NOSC has been developing and is presently testing the Remote Unmanned Work System (RUWS) to provide the technology base necessary for performing engineering and scientific tasks in the deep ocean. The RUWS has stressed operational versatility in its design to accommodate a variety of missions such as recovery, repair, implantment, survey, documentation, and oceanographic data gathering. The work unit of the RUWS, the vehicle itself, has a high-resolution pre-formed beam Vehicle Search Sonar (VSS) for performing local-area search and obstacle avoidance and passive directional hydrophones for pinger tracking and homing. Real-time black and white 525-line-resolution television provides visual data to the operator while a 70-mm still camera can be used for photographic documentation. The TV cameras are mounted on a pan-and-tilt unit which can be manually controlled or used in a

head-coupled mode in which the TV cameras are slaved to the operator's head motions, which provides a distinct sense of being present at the work site. The work is performed by a two-arm manipulator system: one a relatively simple four-function, rate controlled heavy grabber, and the other a seven-function, position controlled, highly articulated manipulator for which special tools have been designed.

The system's primary cable connects the surface controls to the RUWS vehicle through a Primary Cable Termination (PCT) unit. The work vehicle is tethered to the PCT with a slightly buoyant, very flexible vehicle tether. A Motion Compensation Deck Handling System (MCDHS) performs the dual function of handling the vehicle and PCT during launch and recovery and reducing in-water motions of the PCT and dynamic loads on the primary cable. To simplify surface handling, the PCT and vehicle are launched and recovered by the MCDHS while mated together piggyback fashion. At operating depth, the vehicle is undocked and the vehicle tether is paid in and out on command from a storage reel on the PCT. The command center for the RUWS operations is contained in the control van and includes controls and displays for the work vehicle and the PCT, as well as real-time navigation CRT displays. This adaptable system is developing the technology that will extend man's work capability in the sea to 20 000-foot depths. This means that 98 percent of the ocean floor can be explored, developed, and worked.

SUBMERSIBLE CABLE-ACTUATED TELEOPERATOR (SCAT)

As originally configured, SCAT was built to act as a test-bed demonstration vehicle primarily for the purpose of evaluating head-coupled television. It is currently being reconfigured as a light-duty inspection/work vehicle capable of operating to 2000-foot depths.

SCAT can be considered an intermediate vehicle between SNOOPY and CURV. Tethered by a multiconductor cable, SCAT carries a black and white television camera with one 250-watt quartz iodide lamp and a 50-frame, 35-mm camera and strobe mounted on a pan-and-tilt assembly. Sensor capability also includes a sonar system depth sensor and compass. A specially designed electrohydraulic system consisting of an electric motor, fixed-displacement pump, relief valve, and reservoir drives hydraulic motors connected to ducted thrusters and provides maneuverability in both horizontal and vertical directions. In addition, five 2-way servo valves are being added to the system to allow for various work functions which may include a rudimentary manipulator or special-purpose tools. While seated at the control corsole, the SCAT operator views the image relayed by the submersible's television camera on a conventional TV monitor. The orientation of the camera is controlled by a hand-operated pan-and-tilt control. The entire SCAT system

(vehicle, control console, power distribution unit, main cable, and power generator) is designed for transportation by commercial aircraft handling systems and cargo spaces.

SNOOPY

SNOOPY is the smallest in a series of lightweight portable unmanned undersea vehicle systems. It is capable of carrying a TV camera with a 250-watt mercury vapor light source into the sea environment. As such, it is capable of replacing a diver for many tasks for which observation or surveillance is required. The system uses hydraulic fluid pressure of 1500 psi and delivers 1/5 horsepower to each of two thrusters for underwater propulsion. SNOOPY has two unique features: all propulsion power is sent from the surface by hydraulic lines, and an automatic depth-keeping capability is provided by a variable-buoyancy chamber and a depth-feedback system. A small, electrically powered grabber is mounted on the forward end for implanting or retrieving lightweight objects. The vehicle weighs 50 pounds and operates to depths of 100 feet.

ELECTRIC SNOOPY

ELECTRIC SNOOPY, the successor to SNOOPY, differs from its predecessor principally in its propulsion scheme and its depth capability of 1500 feet. This vehicle uses three 1/4-horsepower, oil-filled, pressure-balanced electric motors for thrust in the horizontal and vertical directions. This approach allows the use of a small-diameter tether cable. Ac power, along with multiplexer control signals, is sent down the cable and converted to variable dc motor-drive voltage through motor controllers at the vehicle. Twin pressure hulls house all vehicle electronics in addition to a television camera and a Super-8 movie camera, providing a streamlined and responsive vehicle. The Super-8 camera provides intervals of action footage or a large number of individual frame pictures. The vehicle is 24 inches wide, 40 inches long, and 18 inches high; it weighs 155 pounds in air and is made neutrally buoyant by a rectangular slab of syntactic foam with a density of 36 pounds per cubic foot.

NAVFAC SNOOPY

NAVFAC Snoopy is a small, remote-controlled vehicle system which has been designed and fabricated at NOSC for use by the Naval Facilities Engineering Command during ocean construction work. Its primary uses are optical survey of proposed undersea construction or implantment sites, surveillance and documentation of diver operations, and general undersea inspection and documentation.

The vehicle's design depth is 1500 feet. It employs four hydraulically powered thrusters for horizontal and vertical excursions. The three horizontal thrusters are controlled by a three-axis proportional joystick for integrated forward, reverse, turning, and lateral vehicle motion. The vertical thruster control employs automatic depth- and altitude-holding circuitry with manual override. A television camera is used for real-time viewing, and a Super-8 movie camera provides color photographic documentation. Vehicle instrumentation data, which consist of heading, depth, and altitude, are relayed to the surface by a time-division multiplexing system. All instrument data are digitally displayed at the control console, and an additional "sense indication" display is provided for vehicle heading. The vehicle power, control signals, video signal, and instrument data are multiplexed onto a single coaxial tether of small diameter for reduced hydrodynamic drag and ease of handling.

The NAVFAC SNOOPY System was recently modified to provide improvements to the multiplex, hydraulic power unit, and thruster subsystems. A small scanning sonar subsystem was added to permit target localization and limited area search. Surface and subsurface components of the sonar suite are connected by a small-diameter cable which is attached, at intervals, to the main system tether cable.

Potential applications for this vehicle and others of its type also include implantment of objects on the sea floor (marking pingers, etc) and recovery of both large and small objects. The primary advantages that the small, remotely-controlled vehicles offer are safety, unlimited endurance, low initial and operating costs, portability, and direct availability of remote information to control personnel.

MINE NEUTRALIZATION VEHICLE SYSTEM

NOSC has developed and is testing an Advanced Development Model of a Mine Neutralization Vehicle System that involves the use of an unmanned, remote-controlled, tethered undersea vehicle which is deployed from a minesweeper. The vehicle is used to classify and neutralize sea mines which have been previously detected by sonar. Once a mine has been detected by sonar, the vehicle is launched via the vehicle's specialized launch and recovery system. The vehicle contains its own high resolution scanning sonar and undersea TV system for relocation and classification of the target mine. Once classification has been effected, the mine is neutralized and the vehicle is returned to the ship.

An umbilical handling system automatically stores, plays out, and hauls in the vehicle's umbilical cable as the operational situation requires. Control of the vehicle

is accomplished from a specially designed control console located in the ship's Combat Information Center. A multiplex system supplies power and control to the vehicle while transmitting sensor information from the vehicle to the control console.

FREE-SWIMMING VEHICLE

A robot test-bed submersible is presently being developed to allow demonstrations of new, improved vehicle system technology. The submersible, which is 9 feet long, about 20 inches high, and 20 inches wide, has a modular construction which allows expansion to accommodate additional payloads and new sensor systems as the technology for those systems becomes feasible to demonstrate. The vehicle is designed to follow a set of predetermined program tracks such as a parallel-path search or a figure-8 demonstration run. In this mode of operation, the vehicle is programmed via a computer console and an umbilical cable which is disconnected after the initial preprogramming phase. The vehicle is then allowed to follow this course until its mission is complete. If emergency arises, there are automatic procedures which allow the vehicle to turn on an emergency beacon which shuts off all thrusters and is recovered at the surface. After initial tests with this mode of operation, other methods of vehicle command control and communications will be demonstrated. In particular, an acoustic control link and an acoustic slow-scan television link are projected; and, in addition, a fiber optics duplex communication link is planned. The end result will be a system which is not limited by cable drag and cable-handling problems and one which should autonomously perform rudimentary tasks without direct operator control.

SOLID ROCKET BOOSTER DEWATERING SYSTEM

NOSC has been tasked by the National Aeronautics and Space Administration (NASA) to design, develop, and test a Solid Rocket Booster (SRB) Dewatering System. The prototype dewatering system consists of a tethered, unmanned vehicle (nozzle plug); a control console; and handling, deployment, storage, and support subsystems. The dewatering system will be used to recover the expended SRB cases of the space shuttle system after they have been jettisoned and are floating in the sea.

The nozzle plug (NP) vehicle docks and locks itself into the nozzle of the partially flooded booster case, which is floating in a spar mode with the nozzle 100–125 feet below the surface. Water is forced out of the SRB with compressed air from the surface support ship. When sufficiently dewatered, the SRB goes into a "log" mode, and a sealing bag on the NP vehicle is inflated to seal the nozzle. A hose is then deployed and the remaining water is forced out through the nozzle plug.

Prime power for the system is provided by a 440-V, 400-Hz, 3-phase generator aboard the support ship. This power is supplied to the vehicle through a 600-foot umbilical. The umbilical also contains a 1½-inch air line through which air to dewater the SRB is supplied at 150 psi.

All vehicle subsystems are hydraulically operated. Hydraulic power is provided by two 15-hp motor pump units in the nozzle plug vehicle which provide up to 16 gal/min at 3000 psi.

Vehicle thrust is provided by six 5.5-hp thrusters, four horizontal and two vertical. The horizontal thrusters are controlled individually so the vehicle can move in any horizontal direction without requiring a yaw maneuver. This feature allows the operator to follow the SRB motions during the docking maneuver.

The vehicle is equipped with TV camera and lights and a compass for navigation. Horizontal control can be tied into the compass at the option of the operator for automatic horizontal hold.

The vehicle is 14 feet high; the main body is 30 inches in diameter. Total vehicle weight in air is 3400 pounds.

TECHNOLOGICAL DEVELOPMENT

The Navy continuously leads in advancing technology applicable to underwater requirements. New methods are developed and materials are adapted for underwater use to meet the specific needs of naval programs. Some aspects of technology finding application in underwater service are materials, acoustic and visual sensing equipment, and operational systems.

- current projects

TRANSPARENT MATERIALS

Underwater panoramic visibility is important to the Navy for exploration, research, salvage, and ocean engineering operations. Panoramic visibility improves operating safety, convenience, and efficiency in the undersea environment. The need for improved visibility in all directions during observation and maneuvering is being filled by research in transparent materials technology.

Transparent materials with the required properties are selected and incorporated into pressure-resistant structural designs. The transparent structural assemblies are evaluated under simulated deep-ocean conditions. Large panoramic windows and transparent hulls for manned submersibles have been constructed with acrylic plastic. Acrylic plastic panoramic structural components currently have operational depth capabilities of 2000 feet. Fabrication technology for 78-inch-diameter acrylic plastic hemispheres is being developed for service depths of 3000 feet.

Panoramic windows for optical viewing systems for unmanned vehicles provide abyssal depth capability by utilizing glass-ceramic fabrication. Spherical, 8-inch-diameter windows successfully perform at pressures of the greatest known ocean depth: 36 000 feet.

WINDOWS AND HOUSINGS FOR IR IMAGING SYSTEMS

Surveillance of the ocean surface, as well as secure naval communications, requires infrared energy transmitters and receivers for shipboard use. This equipment, in

order to operate properly, has to be equipped with windows that must be not only transparent to infrared energy but also capable of withstanding the marine environment for prolonged periods of time without significant deterioration of the optical surfaces.

As a result of experimental and analytical studies conducted over a period of several years at NOSC, in-house capability now exists to design and fabricate on contract germanium windows in any desirable shape that are capable of withstanding wave slap and/or immersion to any desirable depth in the ocean. To date, windows in the shape of plane discs, plane rectangles, spherical sectors, and hyperhemispheres have been designed, fabricated, and experimentally evaluated in mountings that minimize stress concentrations due to edge effect. Experimental evaluations, as a rule, include wave slap, hydrostatic pressure, dynamic overpressure, point impact, thermal shock, bio-fouling, and seawater corrosion tests. For arctic applications the experimental evaluation also includes the testing of window heating techniques whose objective is to keep the windows ice free.

Although germanium is the primary material for IR windows, other materials such as ZnSe, ZnS, Al_2O_3, and Ge glass have also been experimented with. These materials hold great promise for multispectral imaging systems that operate both in the visible and IR energy spectrum. To date only exploratory investigations have been conducted with these materials.

HIGH-STRENGTH-TO-WEIGHT-RATIO MATERIALS

High-strength, lightweight steel alloys, aluminum, and titanium are all fairly well developed materials that are used in undersea systems. However, the real advances in retaining high strength while greatly reducing weight appear to be in the further development of plastics, glass, and synthetic fibers. NOSC has an active program in development of transparent materials such as acrylic, glass, and certain ceramics which have very high compressive strength and resistance. Work is progressing in the development of reliable repeatable manufacturing technology and safety certification criteria. A current synthetic aramid fiber, KEVLAR-49, shows great promise as a reinforcing component for replacing glass in GRP (Glass Reinforced Plastic) fiber glass with a 33-percent reduction in volume and a 50-percent reduction in weight for equal strength for pressure housings. The high tensile strength (200 000 psi) and modulus of elasticity (12 000 000 psi) of KEVLAR-49 make it an ideal material for replacement of steel as the strength member in composite cables for undersea use. KEVLAR provides a weight-saving factor over steel of about 6 to 1 and is nearly neutrally

buoyant in seawater. These materials have direct application to undersea systems as pressure hulls, hydrodynamic fairings, structural members, windows, and cabling.

LIGHTWEIGHT UNDERSEA CABLES

A recently completed program has developed a series of deep-sea electromechanical cables which are characterized by high strength and low weight in water. The strength member for these cables is KEVLAR-49, an organic fiber from DuPont, which combines usable tensile strength comparable to that of steel with an in-water weight about one-twentieth that of steel. The component cable, when used as a deep-sea tether, has 5 to 10 times the strength/self-weight capability of conventional steel-armored cables.

Two types of cables have been developed. The first is a 23 000-foot coaxial cable, contrahelically armored with KEVLAR-49 strength members in much the same way that conventional cables are armored with steel wires. It has been operated as the primary support link between a surface ship and the Remote Unmanned Work System (RUWS) described elsewhere in this booklet.

The second cable demonstrates that KEVLAR-49 technology can be used to build cables which combine high strength, multiple conductors, and neutral buoyancy at deep-ocean pressures. The demonstration unit has 20 conductors, a breaking strength of 13 000 pounds, a (jacketed) diameter of 1.0 inch, and a specific gravity between 1.0 and 1.015.

One of the early objections to use of KEVLAR-49 in cables has been its high cost – about $50/lb when processed into a form analogous to cylindrical steel wires. More recent work has shown that the material can be formed into cables in its natural form – a multifilament yarn – at a material cost of $8.50/lb. (This corresponds to a cost of about $1.50/lb for cabling steels which give the same strength.) Little or no penalty in strength is paid, although some reduction in flexure lifetime has been experienced.

FIBER OPTICS IN UNDERSEA SYSTEMS

The use of lightweight strength members means that much of the in-water weight of undersea cables (~90%) is now contributed by the electrical conductors. Such conventional communications technology also means that these cables will form a rigorous limit on system bandwidth. In practice, this leaves the deep-ocean tethered system unable to utilize all available elements of existing sensor technology – eg, high-resolution stereo television, advanced sonars, and simultaneous operation of all sensors.

To eliminate this bottleneck, NOSC is developing miniature fiber optic cables for use with tethered deep-ocean systems. A typical 0.005-inch-diameter optical fiber can give a usable bandwidth of at least 50 MHz over a length of more than 25 000 feet – sufficient to support a sophisticated tethered system which operates at abyssal depths. For comparison, a conventional 0.9-inch-diameter coax will have a bandwidth of about 13 MHz over this same cable length.

The NOSC effort in fiber optic cabling has concentrated on techniques to "ruggedize" the optical fiber, so that it becomes a high-strength cable unit without increase in optical attenuation. Recent progress includes the addition of a KEVLAR-49/S-Glass/epoxy annulus around a buffered optical fiber. The result is a 0.040-inch-diameter cable unit which has a breaking strength of more than 250 pounds (at 2.5% strain). More important, the fiber's optical attenuation is *reduced* by this cabling process, probably because the optical fiber is now held very straight in the structure and is not allowed to form microbends.

For certain applications, miniature opto-mechanical units of this type can be used as the entire tether cable. The Center has also added an electrical conductor and jacket to form a 0.10-inch-diameter electro-opto-mechanical (EOM) cable. The simple optical cable unit can also be assembled as a conductor element into larger cables of arbitrary size, capacity, and complexity.

A duplexer employing color multiplexing is being built and evaluated, allowing two-way communication (ie, command control data to vehicle; sensor data, television, sonar, etc, from vehicle) to be supported by a single optical fiber. Also, a pulse FM transmitter and receiver system is being developed to permit high-bandwidth sensor information to be transmitted by long (>5 miles) optical fibers without the necessity for repeaters. Pulse FM has been shown to offer high performance while maintaining simplicity and low cost at the vehicle end of the link.

PRESSURE-TOLERANT ELECTRONICS

To increase reliability and failure tolerance in the design of undersea systems, the size and number of pressure-resistant containers are kept to a minimum. One way to effect this is to place the electronic components in an oil-filled lightweight case which is equalized to the ambient sea pressure. This technique eliminates implodable volumes, high-pressure seals, and high-pressure connectors, and provides increased heat dissipation. Because of potential cost savings, it is desirable to utilize off-the-shelf products if they can be certified to withstand the pressure. As a result, the suitability of available electrical components for performance under hydrostatic pressure is being investigated, along with measures to assure reliability.

Many types of components have been tested and shown to operate to pressures of 15 000 psi. These components range from simple bipolar and field effect transistors to the latest state-of-the-art charge-coupled-device (CCD) imagers. All tests were performed with the components in a liquid-pressure environment. Liquids used include silicone oil, hydrocarbon hydraulic oils, and fluorinert fluids.

Many systems have been fabricated at NOSC and elsewhere using pressure-tolerant electronic technology. Among them are a pressure-tolerant TV camera (tested to 20 000 feet), an acoustic imaging system, a sonar suite for the USS DOLPHIN (AGSS 555), a beamformer for an endfire acoustic line array, and a diver-worn decompression computer.

DEPLOYABLE UNDERSEA SENSORS

Ocean Technology is being applied to deployable undersea sensors and arrays for undersea surveillance and ASW applications. Critical technologies are being explored for the sensor systems and concepts described below.

FLOATING RANDOM ARRAYS

The technology of forming a coherent array from a concentrated field of freely drifting sensors is being demonstrated. Array element location is accomplished by active sources within the array. The ability to form beams is being demonstrated at sea by measuring the array signal gain and comparing it to the predicted 20 log N where N is the number of array elements. Signal processing, display, and operator interaction architectures are being developed.

BOTTOM-MOUNTED RANDOM ARRAYS

Deployment systems are being developed for distributing a random field of sensors above the ocean bottom. These arrays would be processed in the same manner as the floating random array. They will obtain the same performance advantages while having much longer life.

The deployment mechanism being investigated consists of glide bodies deployed from a suspended master buoy. The winged anchors glide away from the master buoy laying a data link connected to the master buoy, and release buoyant acoustic sensors upon impacting the bottom. The acoustic data are collected and conditioned at the master buoy for transmission to the surface or to shore. The resultant array would be a dynamic, randomly distributed, coherently processed sensor. Larger arrays may be obtained by connecting several master buoys to a common data link.

WATER-INFLATED BALLOON ARRAYS

Feasibility studies are being conducted on the performance and construction of large inflated spherical shell arrays. These three-dimensional arrays would have unique beams to obtain high acoustic performance. Because of the cylindrical symmetry, physical orientation of the array is not required.

ARRAY SHAPE MEASUREMENT

Beamforming for towed, deployed, or suspended line arrays is often based upon the assumption that the array is straight and thus relative element locations are known. NOSC is developing methods of measuring the shapes of connected arrays so that the straightness constraint may be relaxed. This results in improved array gains, improved performance through intentional distortion to eliminate the port-starboard bearing ambiguity, and improved SNR from the quieter condition of a slower towing speed.

Two methods of array shape measurement are being investigated. The self-cohering method uses signals from sources such as distant surface ships to measure the differential element-to-element arrival time. These measurements coupled with the known element-to-element separation are used as data for a least square fit

algorithm to determine array shape. The second method uses heading sensor and tow velocity measurement as data for a hydrodynamic model of the array motion. By taking into account the drag parallel and perpendicular to the array tow direction, the array shape is predicted.

ADVANCED UNMANNED SEARCH SYSTEM (AUSS)

The Navy has a need to locate and classify man-made objects on the sea floor to depths of 20 000 feet. Deep-ocean search is a complex process consisting of a large number of operations, performed under widely differing field conditions, in a highly variable environment. It requires the use of sophisticated systems to look for objects the shape and size of which may be unknown.

The AUSS program is a systems approach to the development of the necessary deep-ocean search equipment which will provide the Navy with the needed tools to conduct a deep-ocean search operation. It will culminate with the design, fabrication, and testing of prototype Advanced Unmanned Search Systems. Prior to the design of these items, however, extensive analysis and development of search technologies will be undertaken. Because of the complexity of the search problem, quantitative guidance is required to isolate those areas of technology in which improvements will significantly enhance search.

The Advanced Unmanned Search System has as its major goal the improvement of the Navy's deep-ocean search capability by an order of magnitude within the next decade. The main element of the AUSS program is the AUSS model. It is a large-scale search simulation computer model developed for systems and hardware tradeoff studies. The model assists in the selection of appropriate search hardware and predicts the performance of a final AUSS configuration. The model accepts a number of inputs to specify the search scenario and sensor platform type and then calculates the search figure of merit (mission time), search performance, and even details of a suggested sensor platform. The figure of merit is useful when comparing different platform types, search tactics, or other variables in the search scenarios.

The second part of the AUSS program is sensor evaluation, including at-sea calibration and testing against known targets. The AUSS sensor evaluation effort is involved in acquiring empirical data on the performance of various sensors and related hardware components as they relate to the complete search operation. The tests are designed to provide a totally independent comparison of these important subsystems to supply field data by which the AUSS computer model can be validated or, where necessary, improved.

The third phase is to conduct a tradeoff analysis of the critical search-related parameters in preparation of an analysis of the advanced search concept. Candidate platforms (towed and free-swimming) are being compared to identify a potentially advanced search configuration. Utilizing the computer model involves, first, a performance comparison of different platforms and, second, a sensitivity study to determine the effect of changing important search variables. The data will supplement other phases of the AUSS program by identifying critical search technology areas requiring further evaluation or development, and thoroughly exercise the AUSS computer model.

ADVANCED DEEP-OCEAN SEARCH SONAR (ADOSS)

The Advanced Deep-Ocean Search Sonar (ADOSS) is being developed to provide an acoustic sensor system which can significantly improve the search rate in deep-ocean search operations. The system should have the capability of detecting and classifying man-made objects on or above the ocean floor with reasonably low false-alarm rates. The primary reason for the expected improvement in performance provided by ADOSS is its ability to observe targets throughout 360 degrees of azimuth around the search vehicle aboard which the sonar is mounted. This wide viewing sector provides many acoustic "looks" at varying target aspect angles which enhance the target classification process. With these needed improvements, the sonar information to be presented will be greatly increased. Acoustic target data can then be displayed to approximate the shape of the unknown target to the human observer.

ADOSS offers an order-of-magnitude improvement in acoustic search rates over the conventional Side Looking Sonar (SLS) that utilizes only one fixed sonar beam to illuminate the target. It is known that the availability of better target clues can lead to a well defined target classification system. ADOSS is a logical step in achieving the goal of a totally automated sonar search system using not only conventional towed platforms but "free-swimming" vehicles as well.

OPTICAL IMAGING

For the past several years, NOSC has been involved in the development of advanced optical imaging systems, with the hope of improving underwater viewing ranges, image resolution, and display systems. Several demonstration systems have been fabricated. Comparison testing was conducted to experimentally evaluate the performance of these systems. In particular, conventional underwater systems and systems which use various backscatter reduction techniques to

improve underwater visibility were tested. Comparison data were obtained for all systems under similar test and water-property conditions. Resolution capabilities of the various systems were measured as functions of viewing range, target contrast, and water clarity.

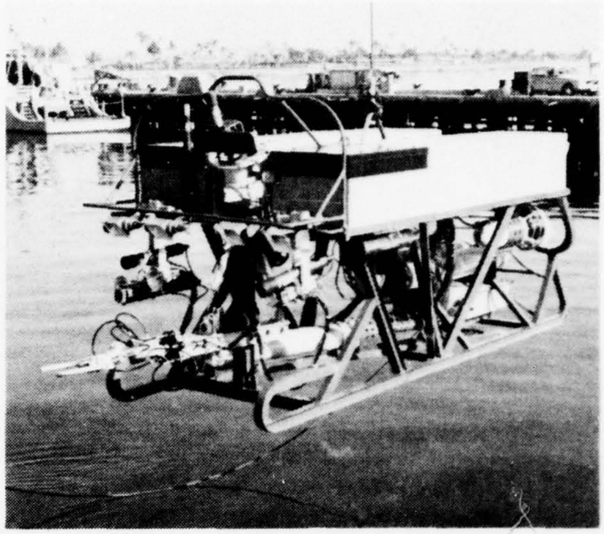
To predict the performance of future television systems, studies were conducted to determine optimum components which could be used for each system. Computer simulations were then used to obtain viewing-range capabilities of the hypothetical systems. The effects of various parameter changes such as field of view, source-receiver separation, and receiver sensitivity were also investigated. Once the detection and image contrast criteria of a receiver have been established, operating ranges of a given system can be determined.

A handbook of advanced underwater optical imaging systems has been published which presents the results of these investigations and a means of theoretically evaluating various image systems. This has been extremely valuable to people in the Navy who are responsible for evaluating proposals and choosing an optimum design approach for large Navy procurements.

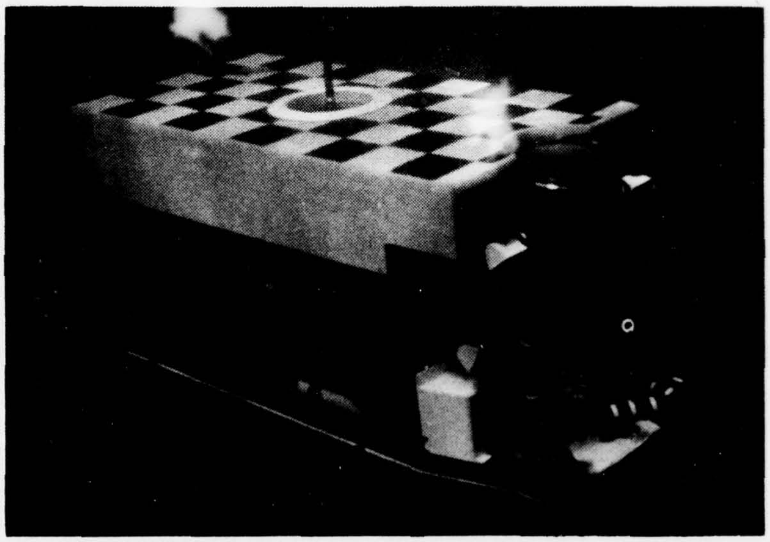
REAL-TIME OPTICAL MAPPING SYSTEM (ROMS)

The NOSC Real-Time Optical Mapping System (ROMS) successfully completed its first in-ocean test at the San Clemente Island test range during September 1977. ROMS is an advanced optical viewing system capable of reducing the detrimental effects of backscatter through the use of the volume scanning principle. The system consists of a flying-spot scanner in an underwater transparent acrylic housing approximately 9 feet long and 2 feet in diameter. The light source is an argon ion laser which is mechanically scanned to illuminate a 120-degree fan beam. The resulting system will provide real-time optical pictures of the ocean bottom from a 120-foot height with a 400-foot swath width. The system is towed at any speed from 0 to 5 knots to provide the vertical sweep.

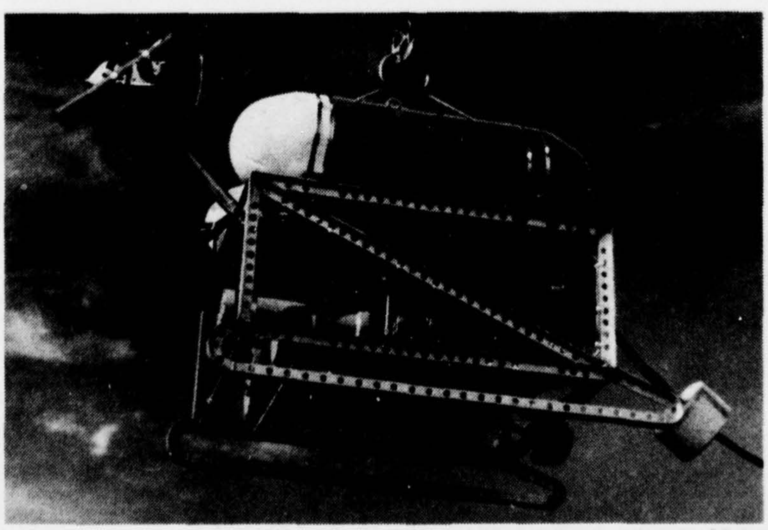
Images made with the ROMS at the NOSC transducer facility of divers swimming through the scanned laser beam have demonstrated the resolution quality obtainable with the present configuration. The divers were clearly recognizable even down to the fully sleeved suit of one diver and the short-sleeved suit of the other. In the original data, such small details as the pressure gauges were clearly distinguished. The system is presently undergoing fine tuning for optimum performance and is scheduled for at-sea mapping demonstration tests at San Clemente Island in the near future.



CURV III.

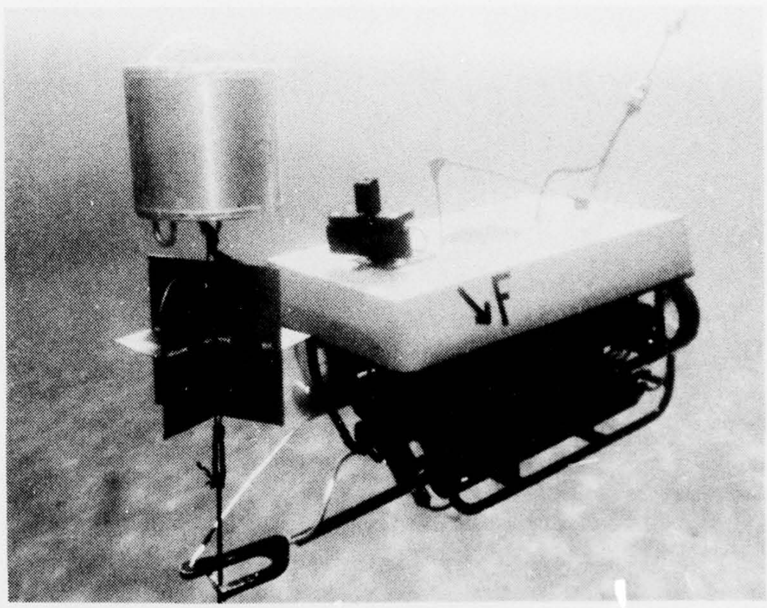


REMOTE UNMANNED WORK SYSTEM (RUWS).



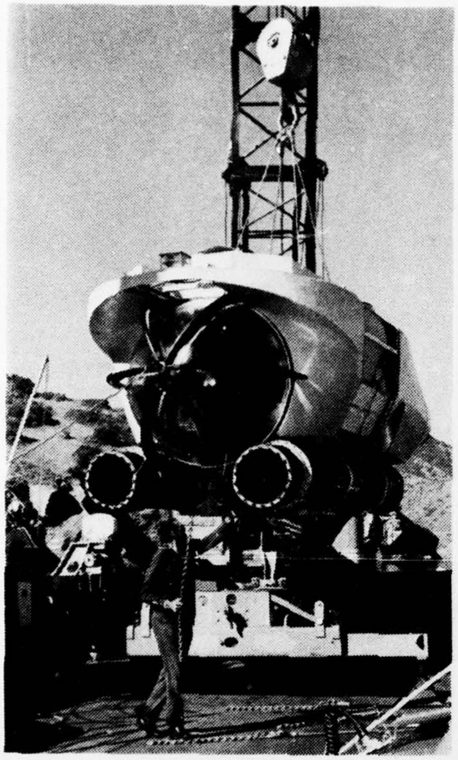
SUBMERSIBLE CABLE-ACTUATED TELEOPERATOR (SCAT).

ELECTRIC SNOOPY.

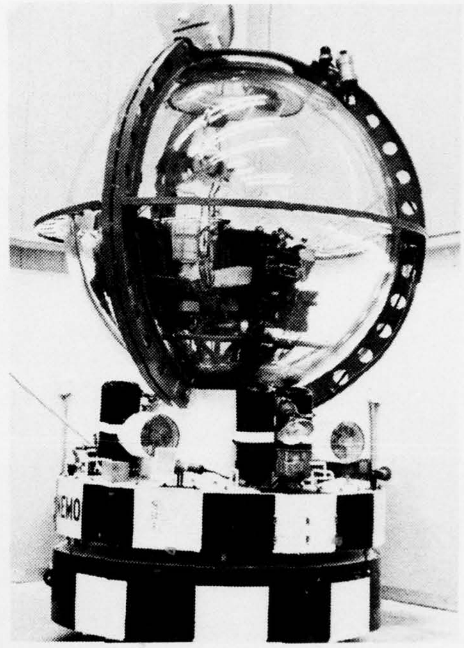


NAVFAC SNOOPY.

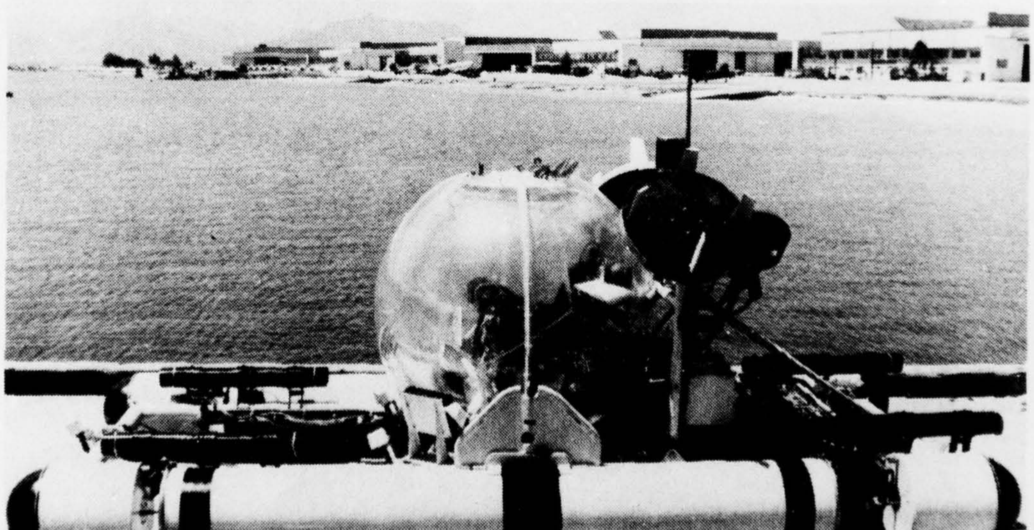
FREE-SWIMMING VEHICLE.



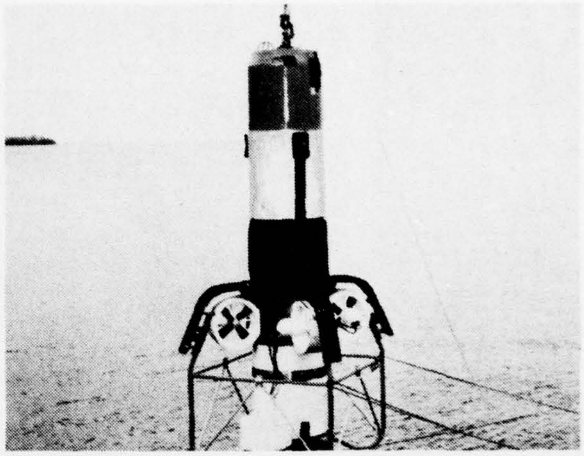
DEEPVIEW.



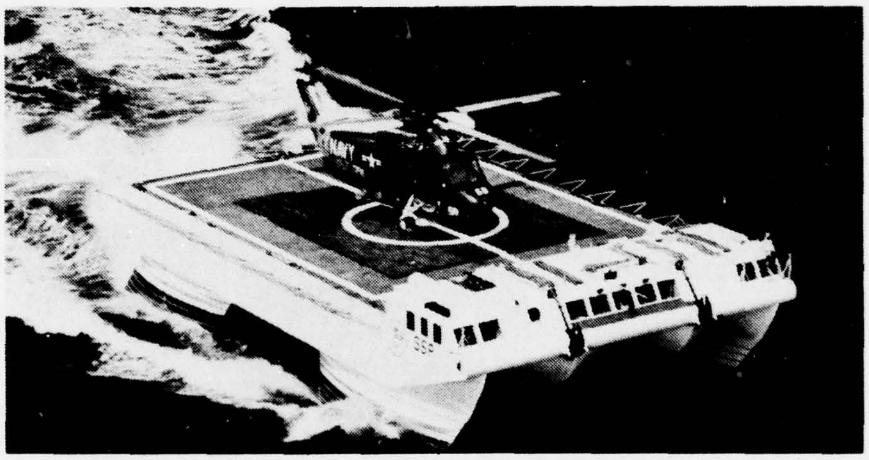
NEMO.



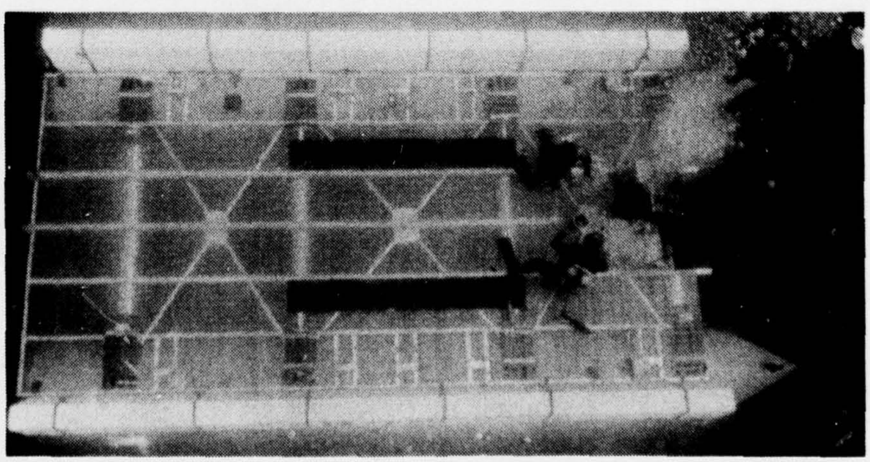
MAKAKAI.



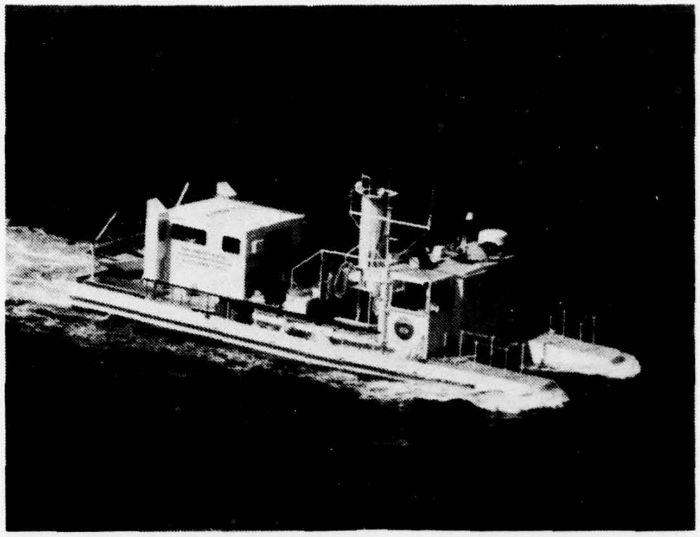
SOLID ROCKET BOOSTER DEWATERING SYSTEM.



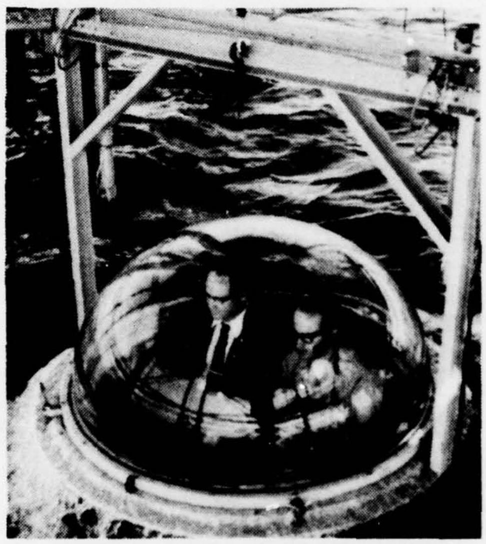
STABLE SEMISUBMERGED PLATFORM (SSP).



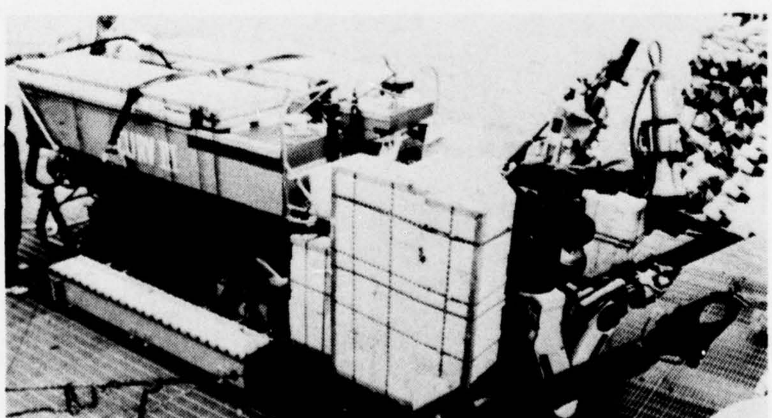
LAUNCH AND RECOVERY PLATFORM (LARP).



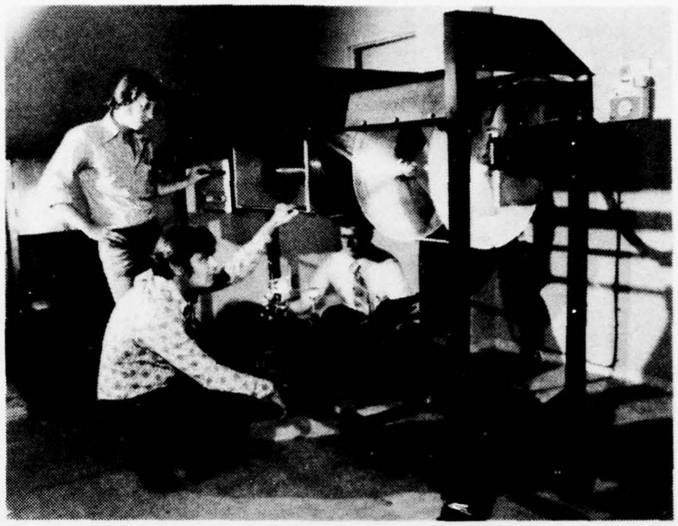
SEA-SEE UNDERSEA OBSERVATION PLATFORM



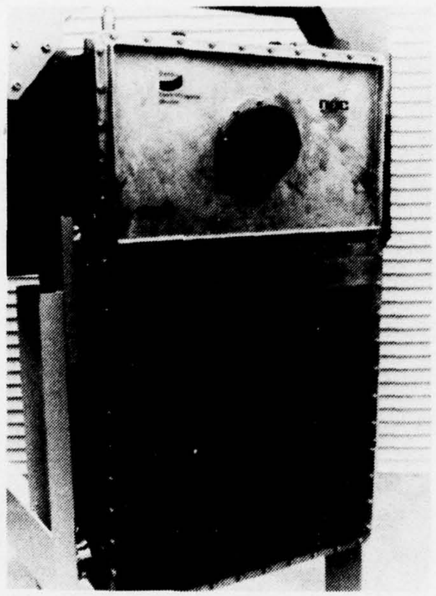
OCEAN RESEARCH TOWER/
ACRYLIC ELEVATOR.



WORK SYSTEMS PLATFORM (WSP) (MOUNTED ON CURV III).



REAL-TIME OPTICAL MAPPING SYSTEM (ROMS).

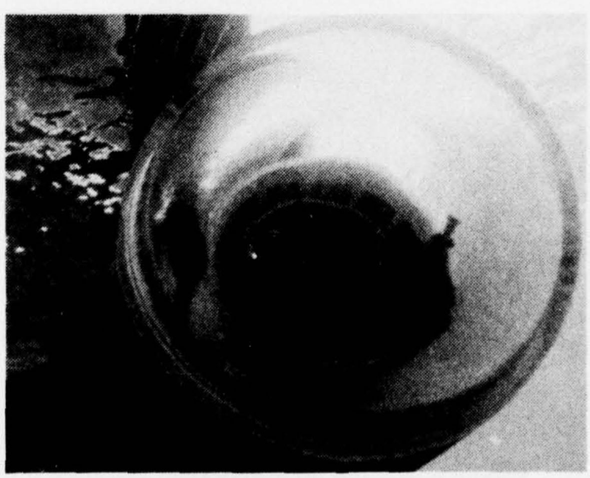


ACOUSTIC IMAGING SYSTEM (AIS).

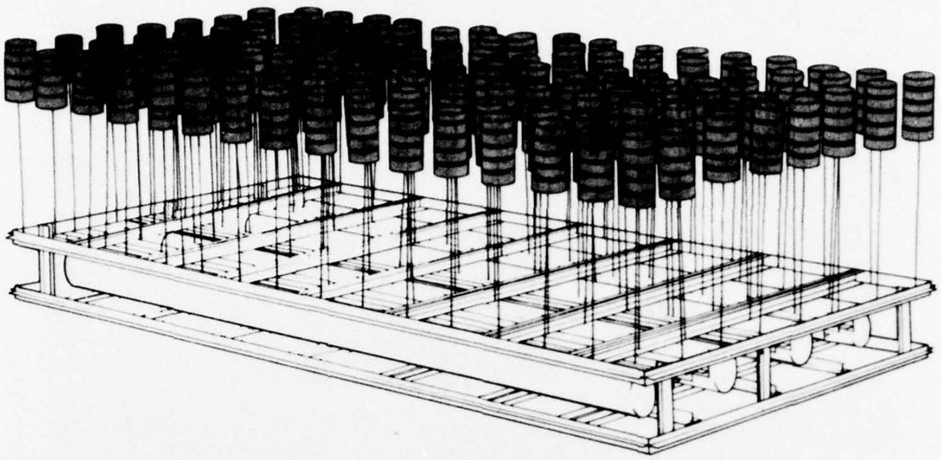
THE THIN, LIGHT FIBER OPTICS CABLE AT RIGHT REPLACES THE STANDARD CABLE AT LEFT.

IR WINDOW.

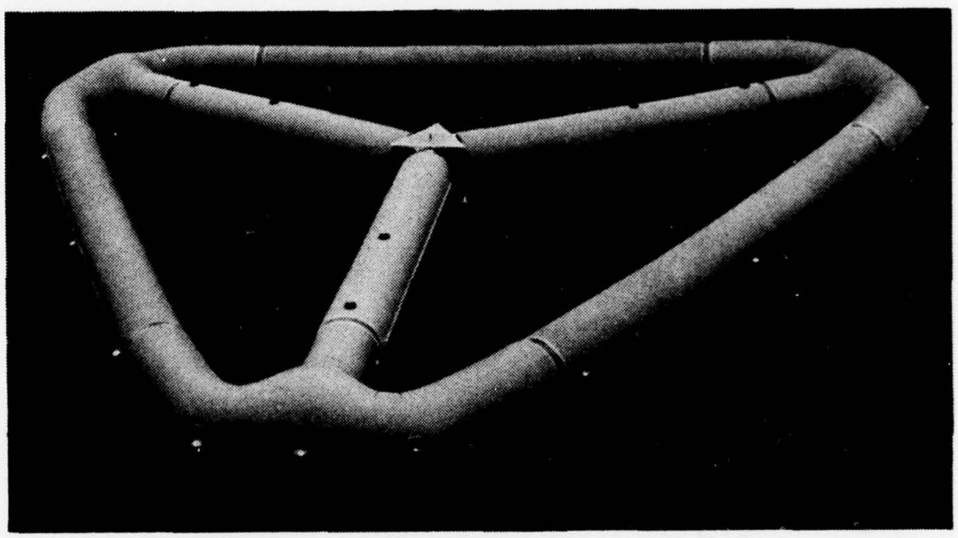
ACRYLIC WINDOW WITH
PANORAMIC VISIBILITY
FOR ALVIN.



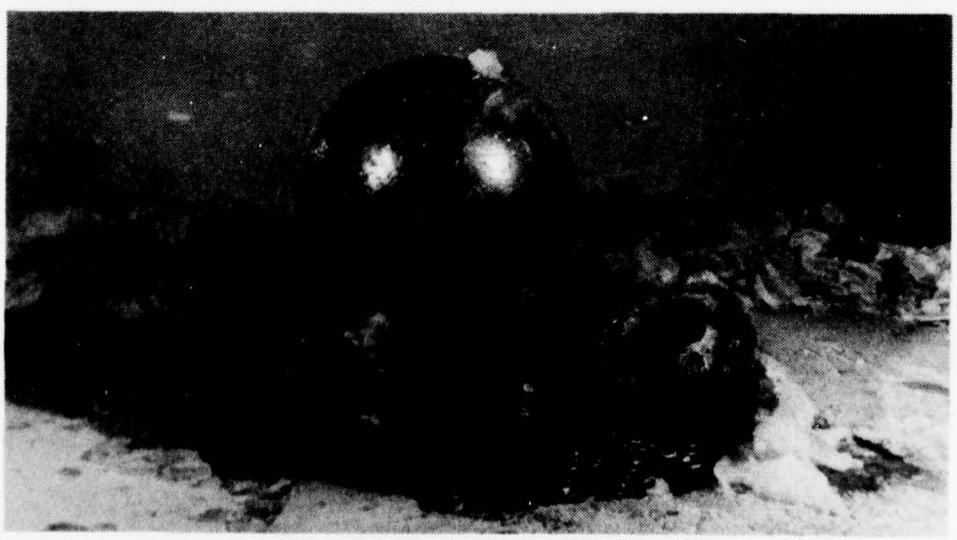
7-FT ACRYLIC DOME FOR SSP



TETHERED FLOATING BREAKWATER SCHEMATIC



INFLATABLE ARRAY FOR ACCURATE POSITIONING OF ACOUSTIC TRANSDUCERS IN MULTISENSOR SONAR SYSTEMS.



ICING-UP OF PERISCOPE OPTICS IN POLAR REGIONS.

SLOW-SCAN TELEVISION TRANSMITTED BY ACOUSTIC DATA LINK

Slow-scan television is undergoing extensive testing at NOSC because it shows promise of providing real-time video information from underwater vehicles by means of acoustic transmission (no cable necessary). Most sensors currently used in underwater inspection, observation, and documentation either are nonreal-time or require a cable to transmit real-time information to their surface support craft. The availability of already installed underwater telephones (UQCs) and low-cost, off-the-shelf scan converters (originally designed for the amateur radio market) is a major advantage.

Two at-sea experiments have been conducted between submersibles and surface support vessels. Twenty-six transmissions have been completed at vertical offsets ranging from 305 to 1220 metres. Straza ATM 504A UQCs were used to transmit and receive the acoustic data and Robot model 400 scan converters were used to convert between fast- and slow-scan formats.

Most received pictures showed some degree of line jitter or graininess. Analysis has revealed that these defects are the result of multipath scattering from the surface and bottom boundaries. Detailed examination of the acoustic geometry indicated that these boundary effects can be minimized by maintaining a more nearly vertical orientation.

ACOUSTIC IMAGING

Inadequate viewing ability is one of the most critical problems faced by operators of manned and unmanned underwater vehicles. The Navy's Deep-Ocean Technology (DOT) project has been developing acoustic imaging systems and technology as one major approach to improved underwater visibility.

Ocean waters absorb and scatter both light and sound. However, these effects limit optical imaging ranges more severely than they limit acoustic imaging ranges. Acoustic imaging is therefore useful over longer distances than optical imaging, and is useful in murky water, where TV and other optical systems are limited. The resolution of acoustic imaging, however, is poorer than that of optical imaging. This implies that acoustic imaging is most useful when optical imaging is limited by turbidity or distance from the object.

One DOT program goal is to develop acoustic imaging systems to extend the viewing ranges beyond those of optical viewing systems particularly in turbid

waters. The program concentrates on developing hardware, generating analyses, and gathering empirical data to improve the performance and reduce the cost and complexity of acoustic imaging systems. In pursuit of these goals, the program is developing an Acoustic Imaging System (AIS) for real-time acoustical viewing from a deep submersible. The design goals of AIS include reliable viewing of a 5-foot object up to at least 100 feet of range over a 22-degree field of view. Also, the program is developing broad awareness of the several technologies involved in acoustic imaging, so systems can be developed to meet many Navy needs.

DISPLAY SYSTEM VARIABLES

As a task for Office of Naval Research (ONR), basic research is being performed to improve the efficiency of remote vehicle operators. The major focus of this task is to conduct research on and identify the key variables affecting remote vehicle operator performance. The range of research includes studies of display system parameters and task demands encountered by the remote vehicle operator and the manipulator operator.

Three general manipulator tasks have been selected for detailed examination. An investigation of the operator's visual task requirements is underway and the perceptual and motor demands for the performance of these tasks are being studied. An experimental laboratory technique has been developed to simulate the degraded underwater visibility conditions which occur as a result of the backscattering of light.

Current studies are being conducted to assess manipulator operator performance under various levels of degraded visibility (clear, moderate, poor) using a conventional TV display compared to recently developed stereo displays. An analysis of the interaction of the perceptual, learning, and task factors which contribute to performance will be made. Findings will be organized so as to provide human engineering guidelines for the design of displays used in remotely operated undersea vehicle and work systems.

WORK SYSTEMS PACKAGE (WSP)

The Work Systems Package (WSP) has been designed to enable the Navy to conduct operations including salvage, recovery, installation, and repair in ocean depths to 20 000 feet. The first work tools developed specifically for remote underwater operations were integrated into a modular package that allows quick installations on several submersibles. The WSP was designed for use with the CURV III and

RUWS unmanned vehicles and the ALVIN, SEA CLIFF, and TURTLE manned submersibles.

Three simplified manipulator arms will handle the tools, perform the work functions, and steady the vehicle. The central manipulator is a seven-function arm that offers considerably dexterity for handling the tools. The two outer arms have no elbow function and act as "grabbers," or restraining and holding arms.

Tools included in the storage box will perform cable cutting, synthetic line cutting, nut torquing, jacking, wire brushing, sawing, grinding, drilling, tapping, chipping, and stud driving. Most are hydraulically powered, but the stud drivers and cable cutters are velocity-powered. All operations are controlled through a multiplexed telemetry circuit from the vehicle. The major system components or the entire package can be jettisoned from the submersible vehicle if a serious emergency arises.

Since the initiation of sea trials in 1975, the WSP has successfully operated with CURV III off San Clemente Island and with RUWS in Hawaii and Florida. Recent laboratory testing has added further operational data, setting the groundwork for development of more-advanced undersea work systems.

TETHERED FLOAT BREAKWATER

The Tethered Float Breakwater (TFB) project is a combined effort of the Naval Ocean Systems Center, Naval Facilities Engineering Command, and US Army Corps of Engineers. The TFB was designed to develop a low-cost, portable breakwater that could be used wherever reduction of prevailing sea conditions is desired – in harbor and marina protection, for example, amphibious assaults, offshore transfer operations, and drilling and dredging operations.

The TFB operates on the principle of energy extraction. Buoyant spheres or cylinders in equivalent volume are tethered below the surface. High buoyancy provides a restoring force to the float as a wave passes; the system acts as a damped oscillator with a natural frequency determined principally by the length of the tether and mass of the float. As a wave passes through the breakwater, the energy of the wave is dissipated in the motion of the floats by overcoming the fluid drag associated with their oscillatory motion. This reduction in energy decreases the height of the waves behind the float field.

A model TFB consisting of moored ballast sections and 12-inch-diameter floats has been fabricated and installed in San Diego Bay. A 2-year test and evaluation

program has yielded a workable system with results applied to the development of a full-scale, bottom-resting model. The ocean hardware consists of ballast assemblies fabricated from steel rail and pipe, synthetic tethers with molded terminations, and floats made from foam-filled automobile tires. The test site is located off Imperial Beach, California, and is subjected to open ocean waves throughout the year.

INFORMATION SYSTEMS AND TECHNOLOGIES (ISAT) PROGRAM

A critical part of every R&D project is the creation and handling of technical and managerial information. Data, specifications, reports, photographs, drawings, correspondence – all must be handled. The effectiveness and efficiency of the project often depend on the ability of the team to handle the information smoothly. The ISAT program is aimed at developing tools to meet these needs.

Part of the ISAT work is technological – developing, applying, adapting new and old technologies and techniques for information handling in a Navy R&D environment. Accomplishments to date include:

- The Undersea Surveillance Library – an automated, secure library of R&D documents related to undersea surveillance.
- Computer-Generated Video Tapes – time lapse video recording of advanced computer displays for subsequent instant replay.
- Microfiche Image Transmission System – a complete system design and study of the feasibility of transmitting Navy personnel records (and other documents) from microfiche to microfiche over long distances by electronic means.
- Video Image Storage and Retrieval – a system using video technology to store and rapidly retrieve a large number of photographic images.
- Video Communication System – a system of many different information sources (TV cameras, computers, microfiche files, video players, document scanners, etc) interconnected through a user-controlled switching system. Users have consoles in their offices, similar to terminals of a computer network. This enables them (and their entire organization) to provide, gain, and share access to information resources in a flexible, effective, and efficient manner.

- Mobile Sonar Technology Data Bank – a data bank of R&D literature related to sonar and underwater acoustics, available on a nationwide basis, and indexed to meet the specialized needs of technological experts.

The ISAT program also deals with the individuals, groups, and organizations served by information systems. This work includes designing, developing or modifying, and implementing information systems to meet ocean engineering needs.

- past achievements

UNDERWATER LIGHTS

Available natural illumination is inadequate for underwater television cameras at depths below 100 metres. Since existing underwater light systems do not provide optimum lighting, a program to provide more suitable light sources was undertaken at NOSC. One short-arc, gas-discharge light which contains mercury, xenon, and thallium iodide and another which contains xenon, cadmium, and zinc have been developed, and initial test results have indicated that the lights perform satisfactorily. Spectral emission of the first light was primarily concentrated in the green portion of the visible spectrum, while for the second light the emission was concentrated in the blue portion – best for the transmission of light in coastal and deep-sea waters, respectively. Compared to the standard thallium-iodide-mercury light, the electrical-to-optical conversion efficiency for the new lights is high, and the start-up and restart times are much shorter.

HEAD-COUPLED TELEVISION

The Head-Coupled Television (HCTV) and Sonar system was built by NOSC to evaluate and demonstrate the degree of "operator presence" which could be obtained with such a system. The operator, wearing specialized equipment, simultaneously views a TV monitor presentation and hears an audio signal containing information from the sonar return signal from the direction in which the camera is pointed. The operator is presented with all the relative visual and proprioceptive information that he would receive if physically present at the underwater camera. The remote pan-and-tilt is positioned by an electrohydraulic position feedback system. This system causes the camera to be pointed in the direction in which the operator is pointing his head. By using this system, the operator not only has his hands free for other tasks but obtains a feeling of being

present in the environment. HCTV systems have been incorporated into the SCAT and RUWS unmanned vehicles.

SUCTION CUP RECOVERY DEVICE

The suction cup used as an experimental underwater recovery device has undergone evaluation tests at the San Clemente Island Test Range. The theory of operation is that a differential pressure is created around the surface of the cup when the unit is affixed to an object and the area inside the cup dewatered. The system has potential use both as a salvage device and as a holding or steadying fixture on items for underwater implantment or construction. The experimental model has successfully recovered objects weighing up to 2000 pounds from a depth of 20 feet in shallow-water experiments. The greater pressures at greater depths will enhance the effectiveness of this technique.

WATER LEVEL DETECTOR

The Water Level Detector is used to sense through the pressure hull of a sunken submarine and detect the presence or absence of water in its various compartments. This information is extremely useful during salvage operations. Neutron radiation techniques convey information through the submarine hull in a non-destructive manner. The source is an americum 241-beryllium, 50 millicurie pellet. The detector is a Texas Nuclear model 9325 neutron detector. A handle, located on the side of the instrument, energizes the electronics and after a period of 1 minute indicates whether there is water present. Depth capability of the equipment is 850 feet. The instrument operates on nickel-cadmium batteries which will provide power for about 8 hours.

HYDRODYNAMIC WINCH (Hydro-Winch)

The Hydro-Winch is a unique approach to the salvaging of very heavy loads from ocean depths through controlled lifting. The winch consists of a floating cylinder with watertight radial inner compartments. Water is transferred between inner compartments to cause the cylinder to revolve like a waterwheel. Close control of lowering, lifting, and holding operations is provided through the operation of the pump and control valves. The outer surface of the cylinder serves as a winch drum, unreeling cable during lowering and reeling cable in during lifting. A large mechanical advantage results due to the moment arm to the cable wraps on the outside of the cylinder. The line tension is automatically protected from overload by the fact that the floating cylinder is in no way restrained except by the amount of water in the radial compartments, which provide a constant load.

A concept has also been evaluated in which the cylinder could be used to free grounded ships. This alternate arrangement would transfer the lifting forces to a horizontal direction to pull stranded ships free in shallow water.

SONODIVER

Deep-ocean instrumented buoys play diverse roles in the exploration of hydrospace. One of the more typical configurations of a deep-ocean instrumented buoy is a gravity/buoyancy-actuated instrumentation capsule such as the Sonodiver buoy. The Sonodiver buoy is an unmanned, untethered deep-diving vehicle designed to operate as an acoustically quiet platform. The cigar-shaped buoy is 11 feet long and 18 inches in diameter, and weighs 450 pounds in air. The vehicle gathers acoustic and environmental data at predetermined ocean depths to 20 000 feet. Equipped with an omnidirectional hydrophone and environmental sensors, the Sonodiver records acoustic data between 10 and 5000 Hz and auxiliary data such as depth, velocity, and temperature.

Vehicle support equipment consists of fluid valves, weight release mechanisms, flotation apparatus, fluid ballast, and a retrieval system. Although gravity/buoyancy control of depth uses a rather simple system, accuracy in following programmed courses requires high quality in design and fabrication.

TECHNOLOGICAL APPLICATIONS

Ideas, designs, and products of other DOD activities and industry are constantly being reviewed for application to Navy needs. Some of the areas under investigation have to do with a proposed very large deep-sea sensor array, synthetic materials for ropes and couplings, and water-inflated fabric tubes for sensor array structures.

- current projects

DUMAND – A LARGE DEEP-OCEAN NEUTRINO DETECTOR

DUMAND, standing for Deep Underwater Muon and Neutrino Detection, is the name of a project started by a group of US physicists for the purpose of making a detector large enough to detect a significant rate of infrequent neutrino interactions, at energies beyond those available even from contemplated future

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particle accelerators. DUMAND may allow the observation of extraterrestrial and possibly extragalactic sources of neutrinos.

The techniques available for detecting high-energy neutrino collisions in the ocean utilize either the light flash the particles produce (Cerenkov radiation) or the acoustic pulse they emit (by instantaneously heating a tiny volume of water). The ocean is simultaneously the target, detection medium, and shield from external disturbances. The detector, at 3000 fathoms, will probably consist of vertical strings of sensors, anchored to the bottom and buoyed. They will be connected by cable to shore. The array will have variable spacing on the strings, with sensors from 20 metres apart near the center to 160 at the periphery, initially encompassing a volume of 1 km^3 (and in the ultimate version perhaps 100 km^3).

The program is in active development now, with research going on at many laboratories and in the ocean near Hawaii. NOSC's primary contribution to the study effort to date has been associated with the ocean engineering aspects of the array and the selection of a suitable deep-ocean site. Supporting studies, preliminary designs, and cost estimates have been generated addressing the important areas of sensors, cabling, signal processing, and installation and maintenance of the array structure. The concept of a small unmanned vehicle which would be dedicated to remote maintenance of the array is being investigated.

SYNTHETIC FIBER ROPE PROGRAM

Since the introduction of man-made fibers such as nylon, dacron, and polypropylene, synthetic fiber ropes have become available for use aboard ships. These ropes are superior to natural fiber ropes in strength, wear, and resistance to rot, decay, and marine fungus. However, the methods of handling natural fiber ropes do not directly apply to the synthetic ropes, and disregard for the different physical and mechanical properties can cause damage and, occasionally, fatal accidents.

The rendering quality of the synthetic ropes – that is, their ability to move smoothly over bitts and capstans without sticking or chattering – is of fundamental interest and importance in marine applications. A good knowledge of the predominant factors such as friction and surface melting is essential in developing effective handling techniques and preventing fatal accidents, excessive surface melting, and premature failure. NOSC is acquiring data to determine the static and sliding friction coefficients of synthetic

ropes on bitts and capstans and the effects of surface heating on different rope diameters.

COUPLING FOR SYNTHETIC ROPE

The introduction of synthetic fiber rope into the fleet has resulted in coupling failures. Analysis by NOSC shows that couplings previously designed for use with manila rope are subjected to severe overloads when used with synthetic fiber rope. As a result of this analysis NOSC has designed and tested a new type coupling to be used for mooring and towing with sea anchoring capabilities. To be manufactured from HY-100 steel or titanium, this coupling will eliminate structural failures, handle larger-size rope, and permit tow speeds to be increased from 4 to 8 knots. This coupling has been accepted for fleet use and authority issued for conversion.

INFLATABLE ARRAY FRAMEWORK

Detection and location of distant acoustic targets by passive listening requires that hydrophones be held in a predetermined spatial arrangement. Typically, hydrophones are placed on a network of buoy-supported cables which are held taut by properly placed anchors. The disadvantages of this approach are that it requires a large number of ships and many man-hours. To overcome these problems, an alternate approach is being developed which utilizes water-inflated fabric tubes to support the hydrophones. The inflation of the fabric tubes is an autonomous process that, once initiated, requires no further assistance from divers or ships save for the placement of additional anchors for very large arrays. An exploratory study conducted using three shapes and three fabrics has shown that this approach is feasible and does indeed minimize the need for surface support. In fact, listening arrays less than 500 feet across can be deployed without surface support.

FIXED ENDFIRE SURVEILLANCE ARRAY – BARRIER LINE

The objective of the Fixed Endfire Surveillance Array – Barrier Line (FESABLE) program was to demonstrate a lightweight, easily deployable, shallow-water acoustic surveillance capability. The approach taken to realize this capability was design and fabrication of an endfire acoustic array with randomly spaced hydrophones. All hydrophone amplifiers and beamforming electronics are at the array (wet end). The power to the array electronics and the signal from the array are carried on a single cable running from the array to shore. A seawater return completes the circuit.

The weight of the 41-hydrophone array and its processing electronics is slightly in excess of 200 pounds. The 18 000 feet of single-conductor shore cable weighs slightly over 100 pounds. The entire array, including shore cable, has been laid from a single 18-foot outboard motor boat (a Boston Whaler).

The present array operates in the frequency range below 300 Hz. Its depth capability is limited only by the length of the cable required to reach shore. Using the present array electronics, this limit is about 35 000 feet.

- past achievements

AIR-FILM TECHNOLOGY

The air bearing is a device in which low-pressure air continuously inflates a flexible diaphragm while a thin film of air escapes through small vents in the diaphragm providing a frictionless surface on which the bearings ride. The capacity of a bearing equals the air pressure times the support area: a bearing with an airflow of 8.85 psi and a 24-inch diameter has a capacity of 4000 pounds. Some of the promising specific applications of air bearings already considered include handling of equipment and vehicles aboard amphibious ships, unloading cargoes directly on a beach by use of surface mats, and bearings for gantry cranes.

INTER-SEAMOUNT ACOUSTIC RANGE (ISAR)

The Inter-Seamount Acoustic Range (ISAR) was established as part of a 3-year study of how sound propagation in the ocean is affected by environmental factors. ISAR consisted of two separate installations: the transmitter, located atop the San Juan Seamount some 200 miles off the Southern California coast; and the receiver, moored over the Westfall Seamount about 200 miles south of the transmitter and west of Baja California.

The transmitter consisted of four low-frequency sound projectors in a buoy-supported vertical line array above a structure containing the necessary electronics and a power source including a nickel-cadmium battery pack continuously charged by a radioisotope thermoelectric generator. Appropriate placement and recovery lines were installed nearby. Programmed to send a 10-minute sequence of long and short signals every 4 hours, the transmitter operated unattended for more than 3 years after it was installed in June 1969.

The receiver consisted of hydrophones and a large spar buoy in a three-point, taut moor over the Westfall Seamount. The data-gathering hydrophones were arrayed beneath the buoy in U-moors. Once a day, on a command from shore, the data recorded at the buoy were transmitted to NOSC, San Diego, via RF link.

The receiver was removed from its installation site in 1972. The transmitter was recovered from the Seamount in July 1976 with the aid of the unmanned submersible CURV III. The nuclear power source was still operating at a predictably reduced power level.

PLATFORMS

The Navy, constantly seeking to incorporate greater stability and operational flexibility in the construction and application of its ships, is exploring the feasibility of stable ocean platforms. In order to keep pace with continuing submersible development, expanding ocean engineering capabilities, and changing logistics requirements, both stationary and self-propelled platforms that reflect advances in hull design and materials technology have been proposed. Having overcome the deleterious effects of wave action energy, stable ocean platforms of varying sizes and configurations can meet the growing needs of sea-based operations. These applications may include such uses as sea control ships, undersea surveillance platforms, tactical air bases, submersible depots, offshore docking facilities, and floating cities.

- current projects

SWATH SHIP

An often and long-sought goal has been to develop ships that have low motions and accelerations in large waves whether at rest or underway. Since 1968 NOSC has been active in the development of such a ship concept, which is known as SWATH, the acronym for Small Waterplane Area Twin Hull ship.

Due to a SWATH's small waterplane area, passing waves produce only a fraction of the buoyancy change of a conventional monohull, resulting in significantly less motion. Also, whatever motion does occur can be further reduced when underway by the use of active fin control since the small waterplane area makes possible near-full control over heave, pitch, and roll. Furthermore, since the draft is greater than a monohull, and the flow into the propellers is more uniform, there is a tendency toward less propeller cavitation and quieter, more efficient propeller operation. Even at rest, or underway at low speed, the small waterplane area, combined with

the spread-out configuration, the twin torpedo-like lower hulls, and fin appendages, produces much less motion in waves than a monohull.

NOSC activity in the SWATH ship development area has centered around three main areas: to explore the basic concept, to advance SWATH technology, and to assist in introducing a SWATH ship into the Navy. This has encompassed a broad spectrum of work including designs of new SWATH platform configurations, theoretical analysis and model testing, and advanced SWATH design concepts. Full-scale SWATH testing and demonstrations have been significantly aided by the NOSC range support platform, the SSP KAIMALINO, a 217-ton-displacement SWATH ship.

The significant reduction in ship motion associated with SWATH-type hulls compared to conventional hulls has been well documented. How this motion reduction affects crew performance has yet to be ascertained. Current research studies are being conducted to derive functional relationships between ship motion and a variety of cognitive, psychomotor, and physiological measures. The results of these studies will provide valuable information for operators in planning deployments with existing vessels, and may significantly influence decisions for development of SWATH ships for the Navy.

SSP KAIMALINO

The SSP KAIMALINO was developed by NOSC to fulfill the requirements for a range support craft for use in typically rough ocean water off the NOSC Hawaii Laboratory. The SWATH configuration was selected for the KAIMALINO's design because it offered the highly desired combination of features unique to SWATH: large usable deck areas and internal volume, and low accelerations and motions in rough seas over a wide range of speeds.

The SSP has now logged several thousand hours at sea conducting a wide variety of tests, demonstrations, and range support operations in sea states up to 6. In addition, helicopter operations in up to sea state 4 have been performed. The SSP is 89 feet in length and 45 feet in width and has demonstrated a top speed of 25 knots using twin gas turbines for primary propulsion. At its cruising speed of 16 knots the SSP has a range of 450 nautical miles. An automatic motion control system is used to provide input signals to activate flaps and canard control fins to provide near-level ride conditions in very rough seas. Automatic heading control and low-speed auxiliary propulsion provide excellent transit navigation and positionkeeping for deployment of hardware, instrumentation, or submersibles.

- past achievements

FLOATING STABLE PLATFORM

NOSC has demonstrated the feasibility of building a modular Floating Stable Platform by extensive hydrodynamic and utilization model studies. With a small water plane area and a large, massive, buoyant base, the platform achieves the much needed stability for safe, efficient operations at sea. Unlike the hull of a displacement vessel (tug boat, destroyer, etc), which is constantly affected by the surface wave action, the large buoyant base is well below the surface wave action and very stable. The surface of the platform is well above the energy of the wave action. The modular approach permits great versatility. The fabrication of the basic platform module could be accomplished by using concrete – a low cost, malleable material – and repetitive forms. Once fabricated, the modules can be arranged in any number of useful configurations. Each project could select a configuration which best meets its immediate need. Some possible uses of the Floating Stable Platform include tactical air bases, municipal airports, nuclear power sites, offshore docking facilities, undersea construction bases, offshore industrial sites, and floating cities. These applications are not only feasible but practical and economical as well.

OBSERVATION PLATFORMS WITH PANORAMIC VISIBILITY

Shallow-water observation platforms have been instrumental in the advancement of present day marine biological research. They have provided the researcher with an unhindered view of the shallow-ocean environment. In addition they have provided a means by which the oceanographer/scientist can obtain first-hand data without the inherent constraints and limitations imposed by the use of diving apparatus.

- current project

SEA-SEE

An innovation in near-surface underwater observation is the research catamaran SEA-SEE. The unique feature of SEA-SEE is an observation compartment which can be lowered between the pontoons of the catamaran to a depth of 10 feet. The ends of the compartment are hemispheres of clear plastic which provide unrestricted views for photography and other research observations. The capsule has

seats for two observers, and, when the capsule is lowered, eye level is at a depth of 6 feet. SEA-SEE has deck-level accommodations for a working complement of up to four scientists and a crew of two. With its range (300 miles), equipment, and observation compartment, SEA-SEE provides a convenient platform for complete views of coastal and near-surface marine life, activities, and environments.

- past achievements

OCEANOGRAPHIC RESEARCH TOWER/ACRYLIC ELEVATOR

NOSC has designed and installed a permanent oceanographic research tower in shallow water (60 feet) approximately 1 mile offshore from Mission Beach, San Diego, California. The stable platform assures continuous oceanographic and meteorologic measurements from a fixed location. Special equipment has been designed to support research performed from the tower. Vertical railway tracks on three sides of the 85-foot tower allow instrument carts to be positioned at any level down to the sea floor. The tower has overnight accommodations for six people.

An underwater, 1-atmosphere, manned acrylic elevator was developed to enhance the versatility of the tower. The elevator accommodated the operator and one passenger for the descent through the 60-foot water column to the ocean floor. The elevator "cage" is a transparent acrylic sphere that provides a panoramic view of the surrounding water. The sphere, which is 5 feet in diameter, is a product of the transparent hull technology developed at NOSC. Presently, the sphere is on loan to the University of New York.

HULL INSPECTION PLATFORM (HIP)

The Hull Inspection Platform (HIP) is a one-man capsule designed at NOSC to provide a shirt-sleeve 1-atmosphere environment for in-shore marine investigation and engineering. The vehicle consists of a twin-pontoon floating support platform on which is mounted an articulated arm with an observation platform. The device is capable of placing an observer to a depth of 20 feet within close proximity of a subject for investigation. This unique tool eliminates the need for shallow-water diving support in many instances. During operations, the compartment is raised to the deck of the support platform for ingress/egress, stowage, and maintenance. The HIP concept lends itself to direct supervision of all phases of marine investigation.

SUBMERSIBLES WITH PANORAMIC VISIBILITY

Small, agile submersibles with panoramic visibility have been found to be ideal vehicles for carrying men and equipment on reconnaissance and sea-floor missions in the ocean. Recognizing this fact, NOSC has pursued programs for their design, fabrication, and utilization. The products of these programs are several systems that differ in concept, structural materials, mobility, and applications. However, with the least investment in size and complexity of supporting equipment, they all provide the Navy with underwater panoramic visibility.

- past achievements

NAVAL EXPERIMENTAL MANNED OBSERVATORY (NEMO)

The Naval Experimental Manned Observatory (NEMO) is a self-contained submersible with a 1-atmosphere environment. The vehicle has been Navy-certified for an operating depth of 600 feet and carries a crew of two (an operator and an observer). In addition to the crew, the vehicle can carry a payload of 450 pounds. The pressure hull is constructed from acrylic plastic and has an outside diameter of 66 inches with a wall thickness of 2.5 inches. The spherical hull is supported by a structural cage. The cage serves two functions: it supports the weight of NEMO, and also provides a shield which protects the acrylic sphere from impact loads. Directly below the cage is a unit containing the main ballast tank, service module, and main battery pack. The vehicle has several modes of operation. It can take on ballast and make a free descent or can drop its anchor and winch itself down. Because of this self-contained anchor and winch system, the NEMO can hover in the water column at any depth with low power consumption. The vehicle has a vertical speed of 30-60 feet per minute and a life support system of 64 man-hours. NEMO was developed by the Civil Engineering Laboratory (CEL), Port Hueneme, California, and is now on loan to Southwest Research Institute.

DEEPVIEW

DEEPVIEW, a two-man submersible with a transparent bow developed by NOSC, is the first submersible to incorporate glass as a significant portion of the pressure hull. Because its operational depth capability potentially exceeds that of acrylic hulls, glass was selected as the material for transparent hull development. This use of glass represents a technological breakthrough that provides oceanographic investigators with maximum visibility in the undersea environment.

The glass hemisphere serves as the forebody of an HY 100 cylindrical mid-hull stiffened with rings, while the aft end is a steel hemisphere containing the electrical pass-throughs and hatch. The 16.5-foot, torpedo-shaped DEEPVIEW weighs almost 6 tons. Having a mission endurance of 6 hours, the submersible was Navy-certified for a depth of 100 feet. Two 5-horsepower motors provide a submerged cruising speed of 1-3 knots and a surface speed of 5 knots. Thus equipped, DEEPVIEW is a small, versatile submersible capable of performing undersea tasks requiring maximum visibility. It is currently on loan to the Southwest Research Institute.

MAKAKAI (Eye of the Sea)

MAKAKAI, a transparent hull submersible, is a two-man, free-swimming submersible developed and built by NOSC. The vehicle has a Navy-certified operational depth of 600 feet. It utilizes an acrylic sphere as the pressure hull; this affords the operator and the passenger an unobstructed, panoramic view of the outside surroundings. The pressure hull is mounted on a frame to which two pontoons are secured. The pontoons house the lead-acid batteries used for the power supply. Each pontoon contains tanks that are used for ballast and trim during diving operations.

MAKAKAI is propelled by two sets of oppositely arranged, cycloidal-thrust units which provide a cruising speed of 0.5–0.75 knot with a maximum speed of 3 knots. In addition, the thrusters provide 4 degrees of freedom for the vehicle by altering the pitch of the propeller blades. The vehicle has a payload of 870 pounds including the crew and can support a mission of 8 hours duration. MAKAKAI is presently on loan to Sea World, Inc.

DEEP SUBMERSIBLES FOR RESCUE, SEARCH, AND SALVAGE

In order to exploit the depths of the world's oceans, the Navy has long recognized the need for deep-diving submersibles to carry out missions of search, rescue, and investigation. As such, it has assisted in the development of submersibles that run the gamut from mid-ocean depths to 20 000 feet, thereby providing access to approximately 98 percent of the ocean floor.

• current projects

TURTLE AND SEA CLIFF

TURTLE and SEA CLIFF, operated by Submarine Development Group ONE, San Diego, California, are identical in design and operation, and are two of the Navy's versatile, deep-diving research submersibles. Having a depth capability of 6500 feet, these self-propelled vehicles are designed for search, work, recovery, and exploration. Each is 26 feet long and weighs approximately 21.5 tons. Primary power is provided by lead-acid batteries. Designed to operate at a maximum depth for sustained periods of time, each vehicle with its crew of three can maneuver underwater for approximately 10 hours at a speed of 1.5 knots while conducting normal search operations. Navigation equipment provides personnel in the sphere with such information as depth above and below the vehicle, speed, distance covered, and true compass readings. The vehicles are fitted with a sonar system, underwater telephone, and a radio communications system. Equipment designed to enhance mission capabilities includes closed-circuit television, transparent viewports, and lights for illuminating the area around the vehicle and the ocean floor. The vehicles are also fitted with a pair of articulated arms, or manipulators, which have a complement of tools for cutting, drilling, and grasping. Mounted on the forward end of the vehicle between the manipulators are baskets that can hold tools as well as small objects recovered from the ocean floor. NOSC is presently assisting SUBDEVGRUONE to improve the reliability and operational capability of TURTLE and SEA CLIFF.

DSRV OPTICS PROGRAM

The objective of this program is to define, specify, procure, test, improve, and support the optics systems of Deep Submergence Rescue Vehicles (DSRV 1 and 2) as well as those of the mother submarine.

Teamed with vendors, NOSC has been resolving problems associated with optical systems including television cameras and lights, pan-and-tilt mechanisms, still cameras, and viewport optics systems. Environmental tests have proven structural integrity.

Statistics are being obtained to establish failure rates. The resulting equipment designs may be used on unmanned or manned submersibles for classification and observation tasks related to reconnaissance, salvage, construction, and rescue missions.

Initially, NOSC laid out an optics suite designed to provide adequate underwater viewing during a rescue mission. Tests conducted at San Clemente Island showed that the suite provided the required optical coverage. Field test data were compared with analytical results to predict viewing capabilities (range and resolution) for a variety of ocean conditions.

Continuing field and repair support is being provided for the optics equipment being utilized by the DSRV vehicles. Required field changes are identified and engineering solutions to the problems are proposed. Upon approval, these field changes are incorporated into the optics equipment program and installed on board the submersibles.

SIMULATED DISTRESSED SUBMARINE

The Simulated Distressed Submarine (SDS) is a submersible structure simulating the upper half of the forward section of a submarine. The unit consists of four hydraulically operated legs, a hydraulically rotatable drum in the center section (which houses the simulated submarine escape hatch), buoyancy and ballast tanks, a removable frangible sail assembly, underwater closed-circuit TV systems, and still and motion picture cameras with associated lighting. This equipment is connected to a control console, located on shore, by means of a power and instrumentation cable. The unit is raised and lowered by means of the buoyancy and ballast system and a shore-mounted winch rigged to a sea-floor-mounted sheave. The SDS was designed for use in the DSRV Test and Evaluation Program. During operations, the SDS is "hauled down" to the ocean floor in a positive buoyancy mode. Once in place on the bottom, the ballast system is activated and ballast tanks are flooded. The unit has been designed for operating in water depths up to 200 feet.

- past achievements

DEEP-SUBMERGENCE RESCUE VEHICLE

The Deep-Submergence Rescue Vehicle (DSRV) is a deep-diving submersible designed to mate with the hatch of a disabled submarine and take aboard the submarine's personnel. The DSRV weighs approximately 65 000 pounds in air and has a displacement of 76 000 pounds when submerged. It is powered by silver-zinc batteries and has a maximum speed of 4.5 knots. It has an operating time of 10 hours at cruise speed with a 30-percent reserve power supply. Maximum operating depth is 5000 feet. The DSRV can be launched either from a

"mother" submarine or from an ASR 21 class Submarine Rescue Ship. During a rescue mission, the vehicle and its support equipment can be loaded on aircraft for "fly away" to a port nearest the disaster area. There, the vehicle can be loaded on either a "mother" submarine or an ASR for the rescue operation. The DSRV, through its many sensing devices, can locate the disabled submarine, mate with either the forward or the after hatch, and take aboard 24 of the sub's crew on each trip for transfer to the support craft. Two such vehicles are in operation under cognizance of Submarine Development Group One, Ballast Point, California. The vehicles were developed by the Deep-Submergence Systems Project Office, NAVSHIPS PMS 395. NOSC is responsible for field test support.

TRIESTE

TRIESTE, the Navy's deepest-diving vehicle, is capable of carrying three men on scientific, search, and recovery missions to depths of 20 000 feet. In 1960, TRIESTE dove to 35 800 feet in the Mariana Trench.

TRIESTE is outfitted with a search sonar, manipulators, and a photographic suite. It has participated in the search and location of the submarine THRESHER and SCORPION and aided in the recovery of an aircraft.

Support during diving operations is provided from the floating dry dock USS POINT LOMA (AGDS 2). Operation, maintenance, and control are under the cognizance of Submarine Development Group One.

NOSC has contributed modifications to TRIESTE's electronic and acoustic, photographic, and high-pressure systems, and redesigned its superstructure gratings to make its topside equipment more accessible. Additionally, a new penetrator cable assembly was designed to eliminate leakage and grounding problems that had severely restricted TRIESTE's operational readiness.

USS DOLPHIN

The Navy's newest research submarine is the USS DOLPHIN (AGSS 555). It is a deep-diving, diesel electric submarine for which the following goals have been established: to determine technical significance of increased depth, acquire operational sea-test data on advanced sonar concepts, and provide design guidance for future submarines. DOLPHIN is 165 feet long and has a diameter of 18 feet. Although the same material and construction techniques are used in present operational submarines, DOLPHIN, with its size and payload, represents the maximum depth capability of a ring-stiffened cylinder constructed of HY 80 steel. DOLPHIN differs from other manned deep submersibles in that it can operate independently, without a "mother" or escort ship, for periods up to 15 days.

In summary, DOLPHIN is an ideal test platform in deep-ocean areas where acoustic conditions are favorable for listening, ranging, and detecting. DOLPHIN was designed to be able to collect scientific data in previously unexplored waters. DOLPHIN is under the operational cognizance of Submarine Development Group One.

LAUNCH AND RETRIEVAL OF SUBMERSIBLES

Sea-state limitation of present day surface support systems to launch and retrieve submersibles is a handicap to operational forces in exploiting the full operational potential of undersea vehicles. Launch and retrieval operations can be made significantly simpler and less hazardous if the relative motion between the submersible and the launch platform can be reduced or eliminated. For this reason, a number of engineering solutions for expediting launch and retrieval operations have been formulated and implemented at NOSC.

- past achievements

LAUNCH AND RECOVERY PLATFORM (LARP)

The Launch and Recovery Platform (LARP) is a 35- by 18-foot towed catamaran designed to provide a stabilized platform for underwater launching and recovering of submersibles. This system is based on the original work proven by demonstrations with the LRT at the Makakai Range. The vehicle can be lowered to a depth of 130 feet by surface support divers or remotely to 200 feet via a tethered power cable. LARP can be positioned in a hovering mode, at any depth between the surface and its operating depth, by means of buoyancy/ballast compartments located in the center of each pontoon. Other sections of the pontoons are utilized as ballast or buoyancy tanks during lowering and raising operations. Buoyancy blocks, mounted above the pontoons, provide added stability while the vehicle is under tow on the surface. Twelve high-pressure air flasks are mounted below the buoyancy blocks and supply the necessary air for deballasting. The vehicle can be disassembled in 1 day for fly-away operations and reassembled on site in 48 hours. It was initially designed to handle MAKAKAI and similar-size submersibles.

SEMISUBMERGED STABLE SUPPORT PLATFORM CONCEPT

In the operation of submersibles that are used for work, research, and observation tasks, NOSC has recognized the need for a low-cost submersible support platform. This initiated a conceptual design effort for a versatile submersible support platform.

The Semisubmerged Stable Support Platform involves the application of NOSC's Stable Support Platform (SSP) concept to the submersible-handling problem. The SSP concept consists basically of two parallel torpedo-like hulls, submerged to a depth of about two hull diameters and attached to an above-the-water platform by four vertical struts. Its twin submerged hulls provide excellent static stability with a large righting moment arm and range of stability. The concept design incorporates the submerged hulls with a platform that has a large working area and center well. The semisubmerged support platform can be maneuvered over the submersible, and recovery can be made through the well with an elevator and gantry crane. Also, the high freeboard of the platform keeps the main deck above the waves and dry even in rough seas. The design of the Semisubmerged Stable Support Platform can provide a stable platform for launch and recovery of submersibles up to sea state 4. With this extended operational capability to sea state 4, weather contingency cost may be reduced, and the submersibles' operational capabilities could be enhanced.

HELICOPTER LAUNCH AND RECOVERY

A project was successfully completed to demonstrate the helicopter launch and recovery of a small submersible. This is one of several technologies needed to enable manned submersibles to operate independently of large surface support craft. Two approaches were used. In the first, a helicopter lifted the Transparent Hulled Submersible from a pier to the deck of an underwater launch and recovery vehicle. The combined vehicle and submersible unit were towed to the operating area with a surface support craft. Upon completion of the mission both were returned pierside and a heavy-lift helicopter off-loaded the submersible.

In the second approach, a heavy-lift helicopter transported the submersible from the pier to the dive site. At the dive site, the helicopter lowered the submersible into the water, detached, and stood by to act as a surface support craft. Then the helicopter reattached to the lifting sling and recovered the submersible. Finally, the helicopter transported the submersible from the dive site to the pier.

This project established the feasibility of using a heavy-lift helicopter for the handling and transportation of small submersibles and other types of swimmer delivery vehicles.

DIVING TECHNOLOGY

The Navy has long taken the lead in the development of diving technology. Advancements in the state of the art for divers' aids, training equipment, and techniques in physiology have enhanced man's ability to attain greater diving depths with greater safety and work efficiency. The following systems represent some recent advances.

- past achievements

ELK RIVER (IX-501)

The ELK RIVER was fabricated to serve such various naval ocean engineering programs as: Man-in-the-Sea, Deep-Submergence Rescue Program, and salvage programs. Originally designed as a Landing Ship Medium Rocket (LSMR 501), the craft was converted to support underwater equipment and test programs. The IX-501 is currently being operated under the cognizance of Submarine Development Group One to support the Navy's deep-diving program. One of the newest systems, the Deep-Diving System (DDS) Mk 2, Mod 0, has been installed on the IX-501 and is being used to train divers in the techniques of

saturated diving. The Mk 2 system consists of two Deck Decompression Chambers (DDCs) and two Personnel Transfer Capsules (PTCs). Divers are subjected to compression equal to the depth they will experience by either air or helium/oxygen mixtures in the DDCs. They are then transported with the same internal environment to the ocean depths via the PTC. The Navy has recently completed the deepest recorded ocean dive, 1010 feet, using the Mk 2 system.

SUBMERSIBLE TRAINING PLATFORM

NOSC has recently completed work on a more rugged, larger version of the Launch and Recovery Platform (LARP) – the Submersible Training Platform (SUBTRAP). SUBTRAP is a 24- by 36-foot platform designed to simulate the deck of a slowly moving submarine and is used for Navy diver training operations. During the operations the platform can be towed at selected depths to 100 feet.

SUBTRAP is comprised of two parallel, 3.5-foot-diameter, fiber-glass pontoons joined by four aluminum cross tubes which support the steel mesh decking, side rails containing additional buoyancy and ballast tanks, and a control console on the forward end of the platform that faces aft and affords the operator an unobstructed view of the platform deck area. To submerge the platform, the main ballast tanks in the fiber-glass pontoons are flooded; this submerges the pontoons and deck, while leaving the side rails on the surface. The side rails contain six sealed sectional tanks for permanent buoyancy and four variable-ballast tanks which are filled with water or air to provide the necessary negative or positive buoyancy. Once the variable-ballast tanks are flooded, the platform is fully submerged. The operator at the control console can now select the depth at which the platform will hover or be towed and keep the platform trimmed by use of the variable-ballast tanks. To ascend, the operator blows the variable-ballast tanks and the main tanks.

Although SUBTRAP's primary function is supporting diver personnel training, its capabilities for lifting (2 tons) and hovering may involve it in salvage and search and recovery tasks.

DIVER'S NAVIGATION SYSTEM

The Diver's Navigation System is an underwater tool designed to aid divers or submersibles in orienting themselves in the ocean environment. The system is composed of two basic subsystems: an acoustic beacon and a receiver. The acoustic beacon functions as the "benchmark" for the diver. The receiver, con-

taining a visual omnidirectional indicator, displays a bearing from the diver to the beacon. The Diver's Navigation System has the capability of selecting one of five beacons, each of a different carrier frequency. These beacons can operate simultaneously. Although in its present form the Diver's Navigation System is basically a locator system, its concept can be extended to a time-navigation system which would use the beacons as reference points to map geographic areas on the ocean bottom. The system has been successfully tested to a range of 550 feet and is designed to operate to depths of 850 feet.

PASSIVE IMAGE INTENSIFIER GOGGLES

Limited underwater visibility has been a major problem affecting the safety, efficiency, and maneuverability of Navy divers. The limitation of visibility can be due to normally adverse lighting conditions, turbid water, or the restricted use of lighting during covert missions. NOSC has adapted a set of dry-land goggles to demonstrate the feasibility of an underwater viewing device that can enhance the diver's ability to see. The design restrictions of size, weight, power, interfacing, and safety required more development than mere application of state-of-the-art concepts; an advance in optics science was necessary.

The intensifier goggles are a self-contained electro-optical device that can be used with a standard diving mask; no bulky power pack or other special equipment is required. The electrical circuits are specially packaged to ensure diver safety. Even when the goggles are not energized, the diver still has adequate peripheral vision through the side lenses of his mask. The goggles are optically corrected for underwater use and work as follows. The optical image is converted to electron image via a photocathode. This image is focused on a microchannel plate intensifier and intensified by an increase in current. Then the electron image is focused onto a phosphorous screen via a 5000-volt gradient, where it is reconverted to an optical image. The amplified light makes the image brighter. This bright, clear image enables the diver to accomplish his task under the adverse, limited-visibility conditions noted above.

NOSC's mission is to be the principal Navy RDT&E Center for command control, communications, ocean surveillance, surface and air launched undersea weapon systems, and supporting technology. Ocean technology provides a broad base support to the NOSC missions as well as many other undersea programs.

Reviewed and approved by
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